The Hubble Space Telescope
Wide-Field Camera 3

March 8, 1998

Executive Summary

The Hubble Space Telescope (HST) project has completed a study on the feasibility of adding a low-cost backup camera to the HST during the 2002 Servicing Mission. This study was requested by NASA Headquarters after extending the HST mission through 2010. The result is the Wide-Field Camera 3 (WFC3) instrument which satisfies this need as well as providing a new and scientifically interesting wide-field, near-UV imaging capability for HST. The WFC3 can be built at very low cost through a development strategy of aggressively reusing existing parts, spares and designs while minimizing management overhead. Development of this instrument is now approved and under way.

Introduction

Since the meeting of the 2002 Instrument Selection Team, NASA has made the programmatic decision to continue operation of HST at least until 2010. (The previous expectation was that the 2005 Servicing Mission would be the final, "deorbit" mission.) The last Servicing Mission for upgrading HST will be in 2002, with the deorbit mission deferred until after 2010. (The current plan is to delete the 2005 Servicing Mission.)

As a result of the decision to extend the HST mission, the Project has initiated a number of studies to understand how to use available resources to maximize HST's scientific productivity and competitiveness until 2010. These studies address issues ranging from the optimal approach to replacing spacecraft parts, to the scientific strategy for HST in its second decade of operation. The topic of this summary is another such study, chartered by NASA Headquarters, which addresses the imaging capability of the HST through 2010.

The Study charter recognizes that in the period 2002 to 2010, an adequate imaging capability on HST may not be assured. In 2010, HST's primary imager, the Advanced Camera for Surveys (ACS), will be 11 years old. The current imager, the Wide Field and Planetary Camera 2 (WFPC2) will be 17 years old. The Space Telescope Imaging Spectrograph (STIS), which has some limited imaging capability, will be 13 years old. This study addresses the feasibility and cost of a backup wide-field camera.

Study Team

The Study was carried out by a small team, with additional contributions from GSFC, Lockheed, STScI and Swales. This team includes Ed Cheng, Lee Feinberg, Eric Mentzell (NASA/GSFC), John Trauger (NASA/JPL), Bob Brown, Chris Burrows, Mark Clampin, George Hartig (STScI), and Wally Meyer, Bob Woodruff (Ball Aerospace).

Bay Selection

In the time frame that we are considering, the radial bay is the most desirable location for such an imager. The most obvious reason is that we would not want to replace any of the axial instruments (in 2002, these would be ACS, COS, NICMOS, and STIS). The radial bay, on the other hand, will contain the mature WFPC2, installed nine years earlier, and except for certain narrow-band filters, entirely superseded by ACS.

Furthermore, the WF/PC (1) instrument is now on the ground, offering reuse opportunities for the returned instrument mechanisms, enclosure, latches, etc. There are significant spares as well for both WF/PC (1) and WFPC2. We have made good use of this commonality for the axial instruments in the past. The residual WF/PC (1) and WFPC2 hardware, as well as ground test fixtures, present a similar opportunity. The technical presentations will describe these opportunities in greater detail.

Finally, the choice of the radial bay for the possible new instrument is indicated by an anticipated thermal issue. There is a power dissipation limitation in the axial bays that may require instrument management in the 2002 to 2010 time frame. (Until that time, all the HST instruments can be left on all the time.) One possible consequence is that parallel and serendipitous observations may be restricted. The radial bay power dissipation, however, is not an issue because it is essentially decoupled from the axial bays, and the external radiator in the radial bay allows for vastly more efficient removal of heat compared with the axial bays. Thus, putting the instrument under study in the radial bay has the potential benefit of greater opportunities for parallel observations, as well as reduced power requirements for detector cooling due to colder sink temperatures for the TECs.

Wide Field Camera 3 (WFC3)

The primary driver for the WFC3 is to provide a backup capability to ACS and WFPC2 imaging capability. The proposed design will meet this goal with an ACS-like 4096×4096 CCD, a simple 2-reflection corrector system, and a filter set which incorporates the most popular filters for the ACS and WFPC2. The pixel size is 40 milliarcsec when projected onto the sky, with a total field size of 160×160 arcsec. This field is slightly larger than WFPC2 (and slightly smaller than the ACS WFC), with resolution that is similar to the WFPC2 PC channel (critically sampled at 500 nm) and slightly better than the ACS WFC channel.

The WF/PC (1) SOFA filter mechanism will be reused to provide up to 48 filter slots. A preliminary filter selection is given in the presentation package, based on currently perceived needs and spares availability. The final selection will be made after considering community input.

In considering the available CCDs for this instrument, it became apparent that current wide-field CCDs, with suitable coatings, are capable of supporting efficient observations down to the near-UV ($\sim$ 200 nm). By selecting MgF_2 coatings for he optical elements, we enable this sensitivity at a slight expense in red throughput. This wide-field NUV imaging capability is unique for HST and opens up substantial new scientific opportunities that were previously not available. In particular, it will enable detection of galaxies in the $z = 1$ to $z = 2$ star-forming epoch in an efficient survey mode. In addition, it promises to provide a new, Cepheid-independent distance scale by allowing the use of post-asymptotic-giant-branch (PAGB) stars as standard candles as far away as the Virgo cluster.

Cost

The detailed cost estimates for these options are provided in the presentation materials. The low cost of these options represents a breakthrough in the cost of HST instruments. This is made possible by stressing the following implementation strategies.

By reusing existing parts, there is a direct savings in hardware costs. Where existing parts or spares do not exist, then build-to-print existing designs provide the necessary functions without nonrecurring engineering costs.

A team of individuals with critical and complementary skills is now trained to develop instrumentation for HST. These people span multiple organizations and disciplines. The HST Project can use this experience to lead an Integrated Team approach where the best expertise is brought in regardless of organization or affiliation. This approach has two distinct benefits. First, the levels of management typically associated with HST instruments can be reduced, which in turn reduces the management headcount as well as improving communication efficiency. Secondly, the cost of the learning curve is avoided because the staff are already expert with HST instrument design.

Finally, integration and testing costs are minimized because we now have optimized approaches to this costly phase of instrument development. Reuse of previously developed fixtures and test equipment provide direct cost savings. Collective experience within the HST team will again ensure that the lowest cost approaches are taken, regardless of institution, and the fidelity and accuracy of plans increase the likelihood of success without unexpected cost increases.

Study Conclusions

Using existing parts and existing build-to-print designs, a highly capable, low-cost backup imaging capability can be provided for HST in the radial bay location. It will provide a unique, wide-field, near-UV imaging capability to open a new observational window that is currently inaccessible.